Overview of Drought Recovery Metrics During a Heavy Rain Event

Or

Why It Took So Long to Improve Drought in CA on the USDM

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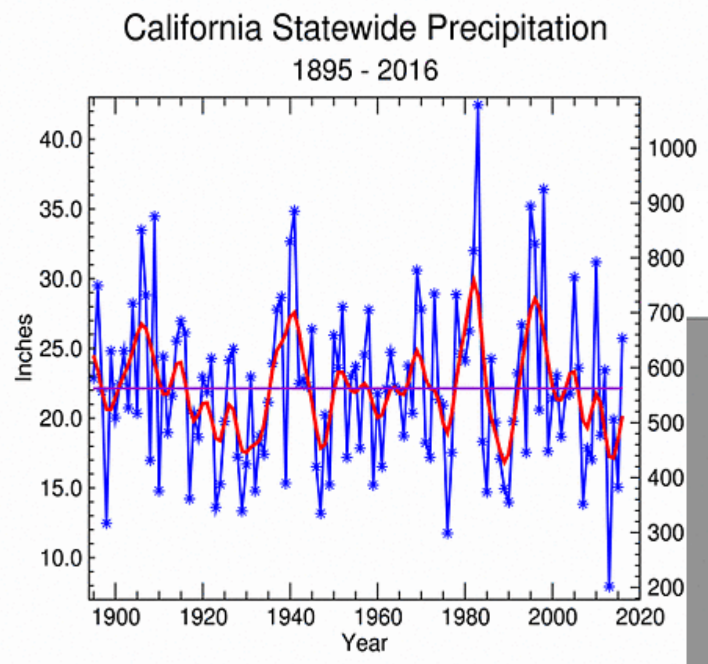
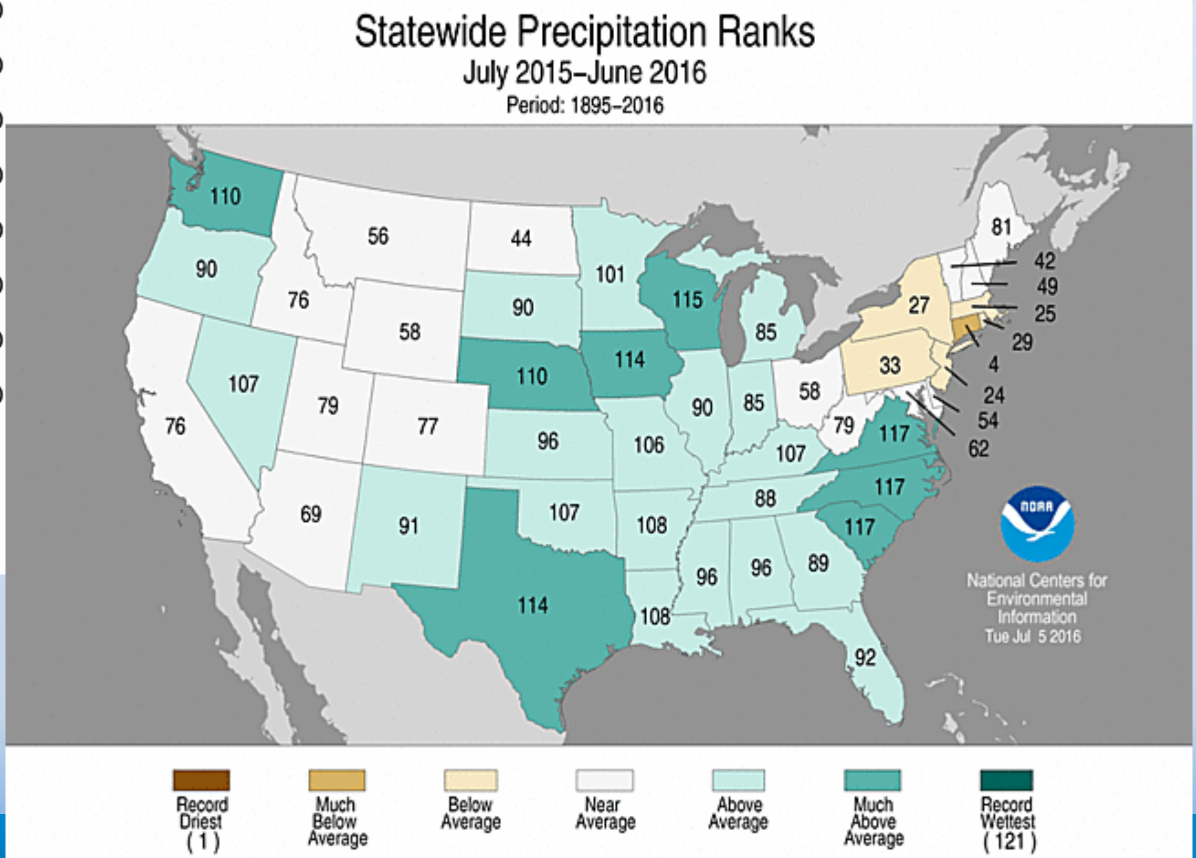
NIDIS User Engagement Workshop *

Incline Village, NV – June 2, 2017

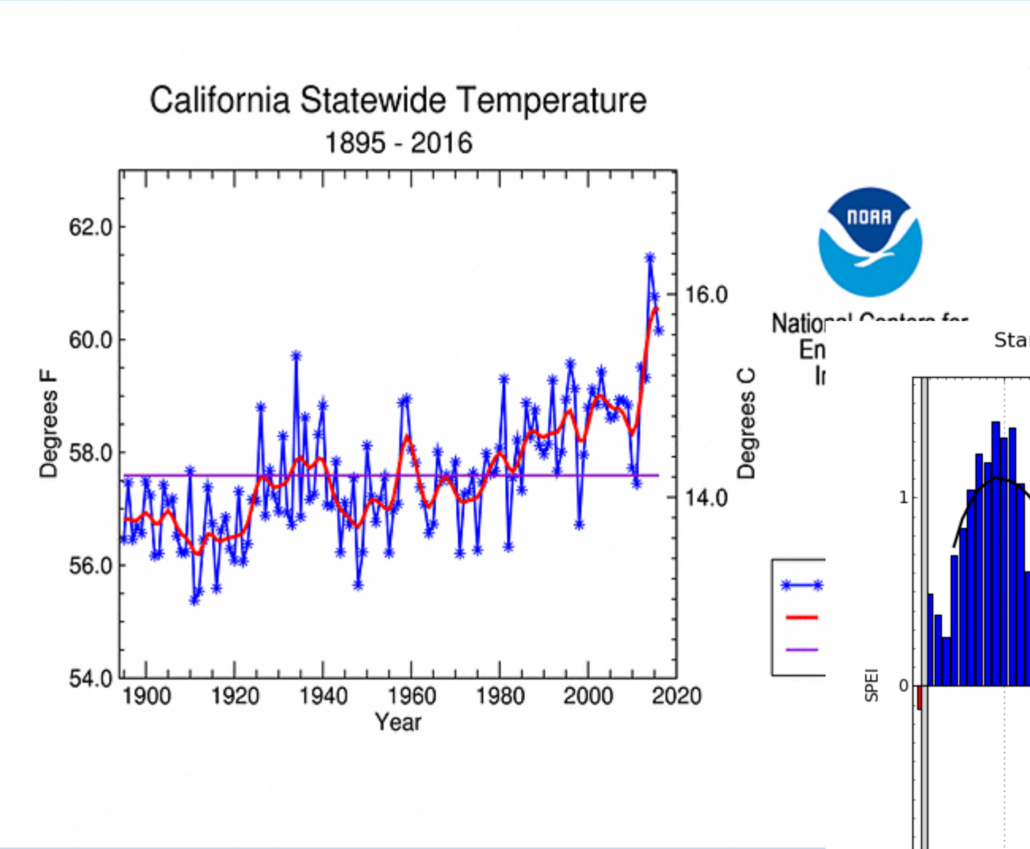
* Do Floods Terminate a Drought? A Workshop on Drought Recovery Tools, Perspectives, and Situational Awareness

Extremely Dry Conditions For Much of Last 10 Years

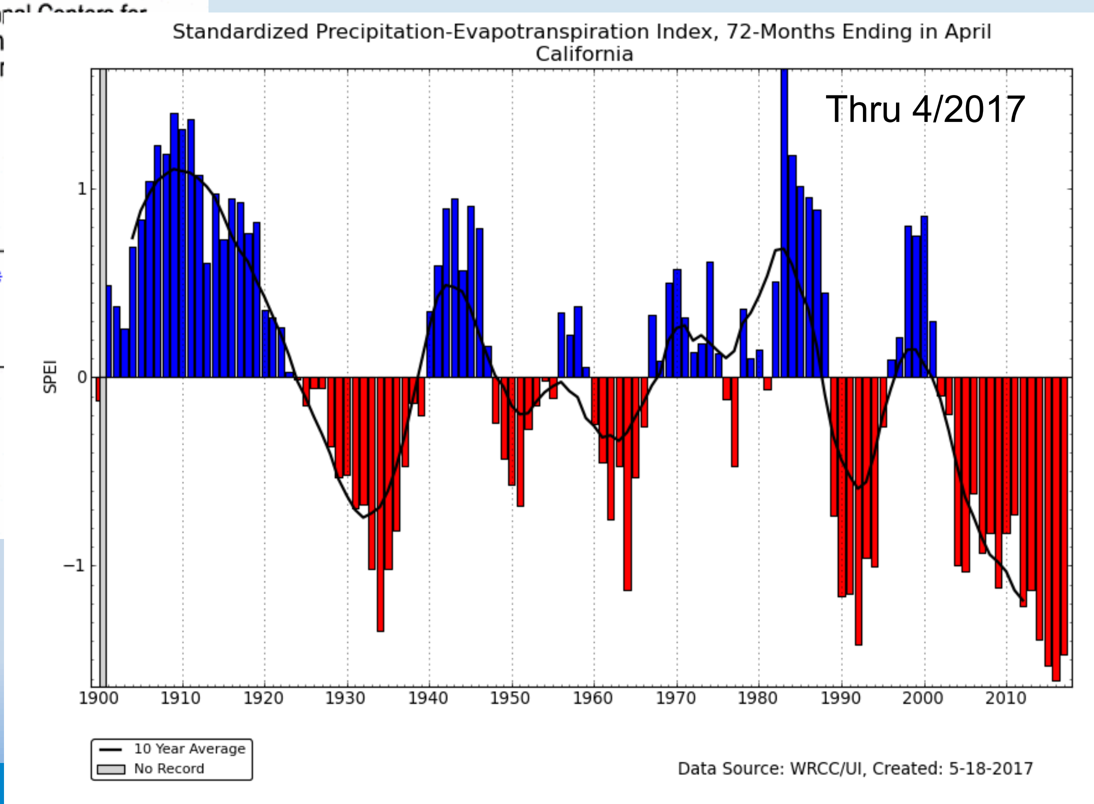




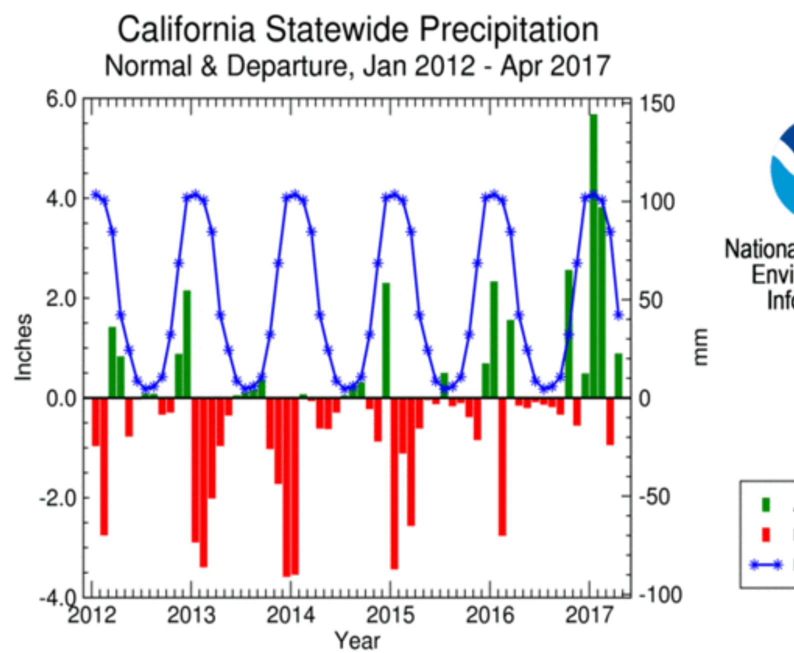
Unusually Warm Temperatures Accompanied the Dryness

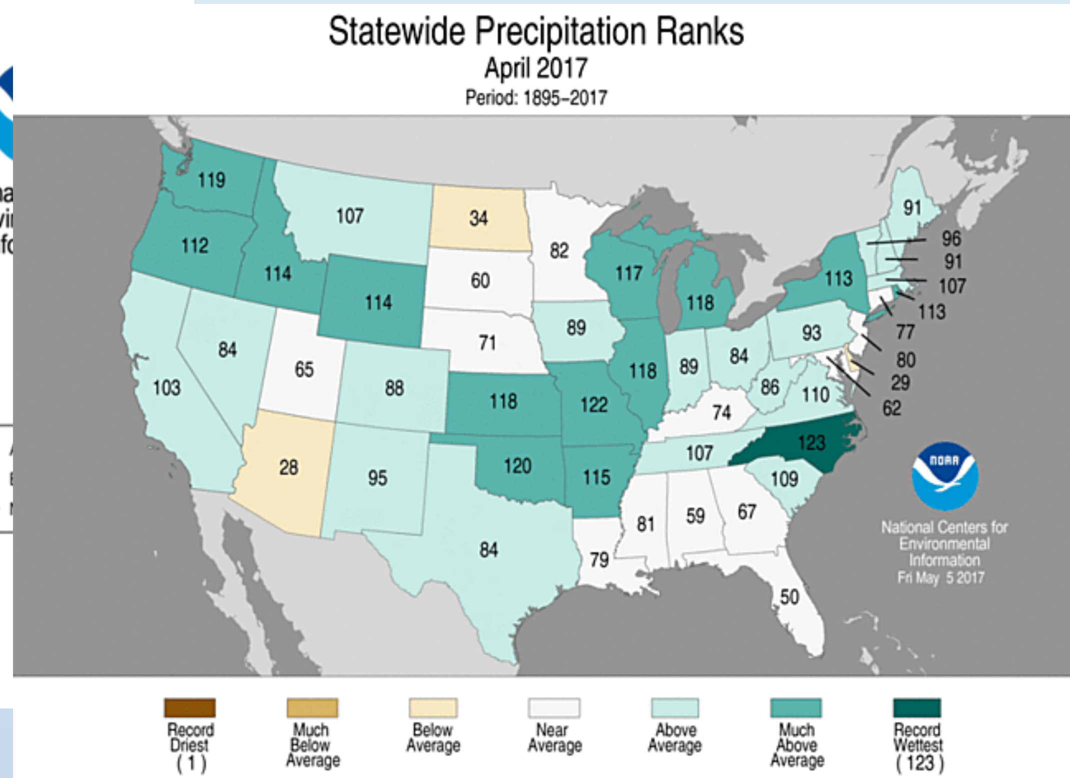


- Record-warm temperatures the last 3 years
- Enhanced ET
- Record-dry SPEI



Wet Conditions Return During 2016-2017 Wet Season





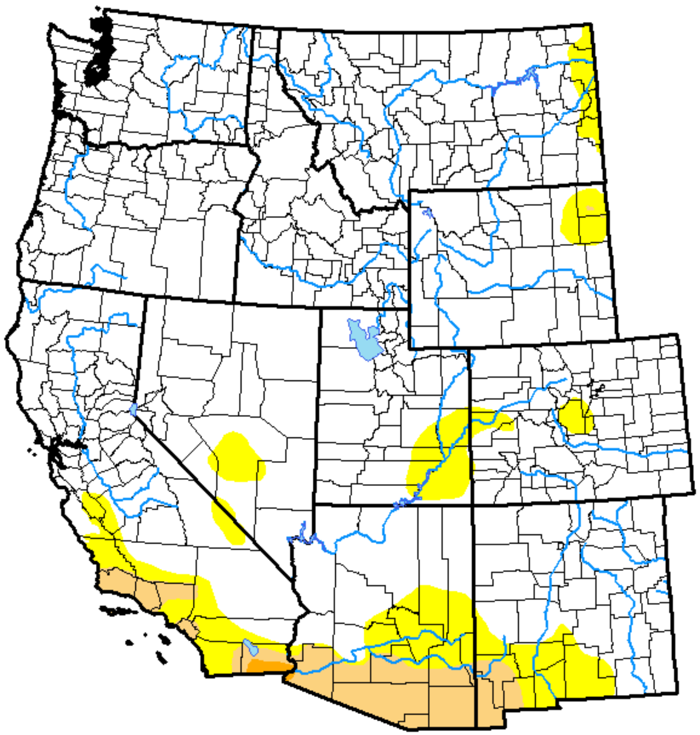
Drought Recovery in CA-NV was Slow

U.S. Drought Monitor
West

May 23, 2017
(Released Thursday, May. 25, 2017)
Valid 8 a.m. EDT

Drought Conditions (Percent Area)

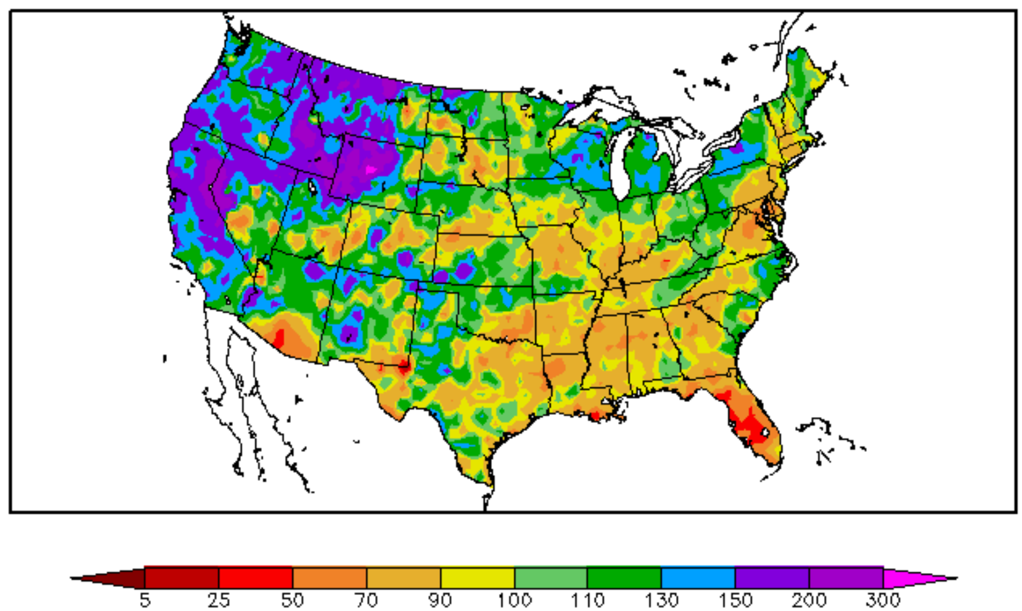
	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	86.38	13.62	4.46	0.16	0.00	0.00
Last Week *05-16-2017*	86.06	13.94	4.49	0.16	0.00	0.00



- CA pcp rank:
  - 4th wettest Oct-Mar
  - 3rd wettest Oct-Apr

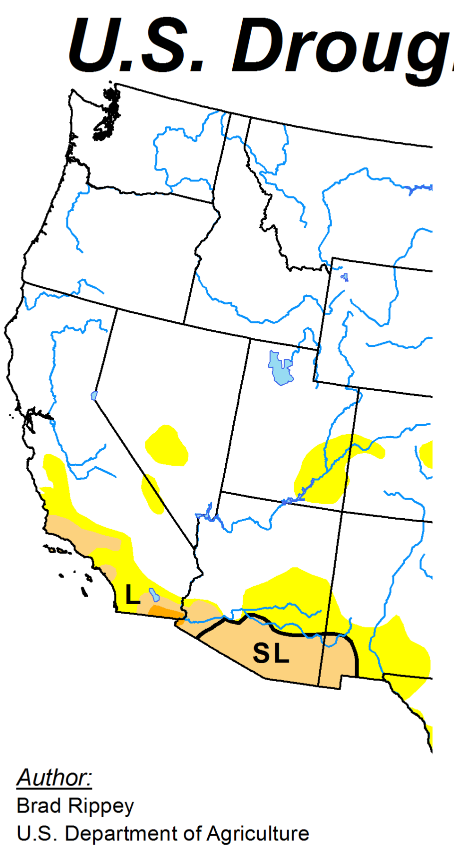
  in 2016-2017

Percent of Normal Precipitation (%)
10/1/2016 – 4/30/2017

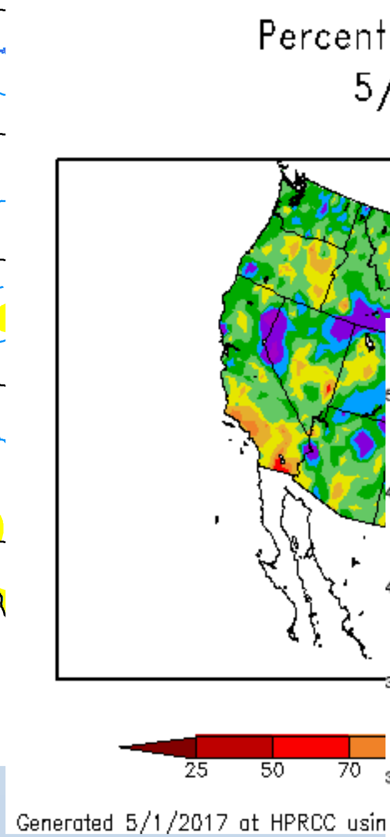


Generated 5/1/2017 at HPRCC using provisional data. Regional Climate Centers

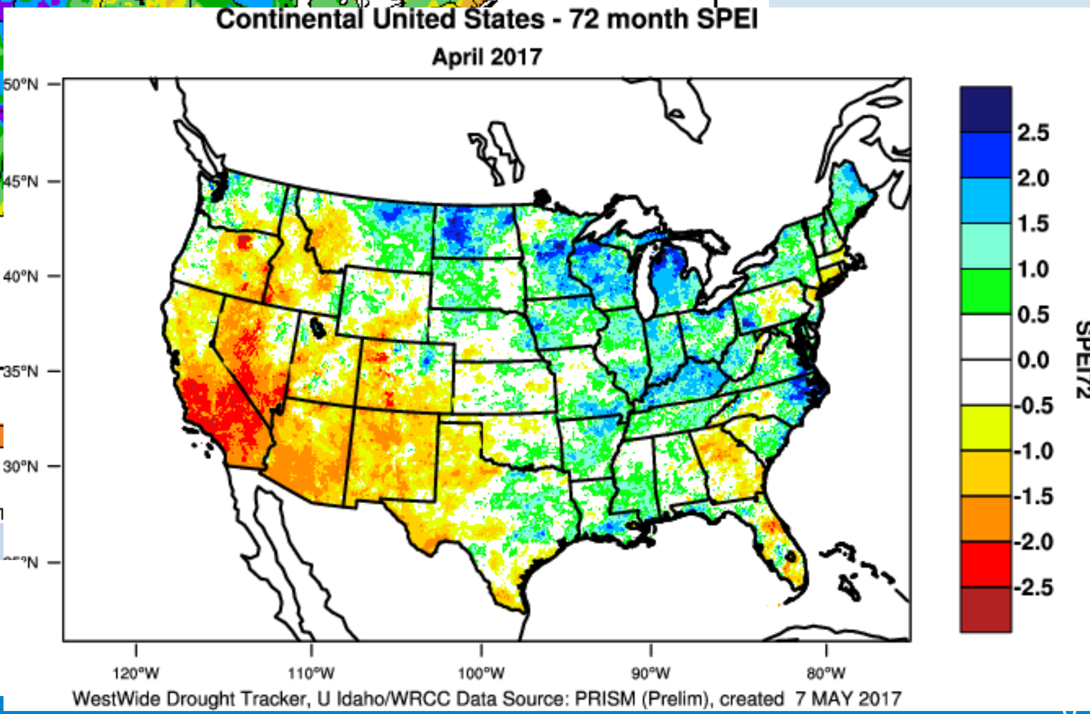
Long-Term Precip Deficits Remain in s.CA



L impact label

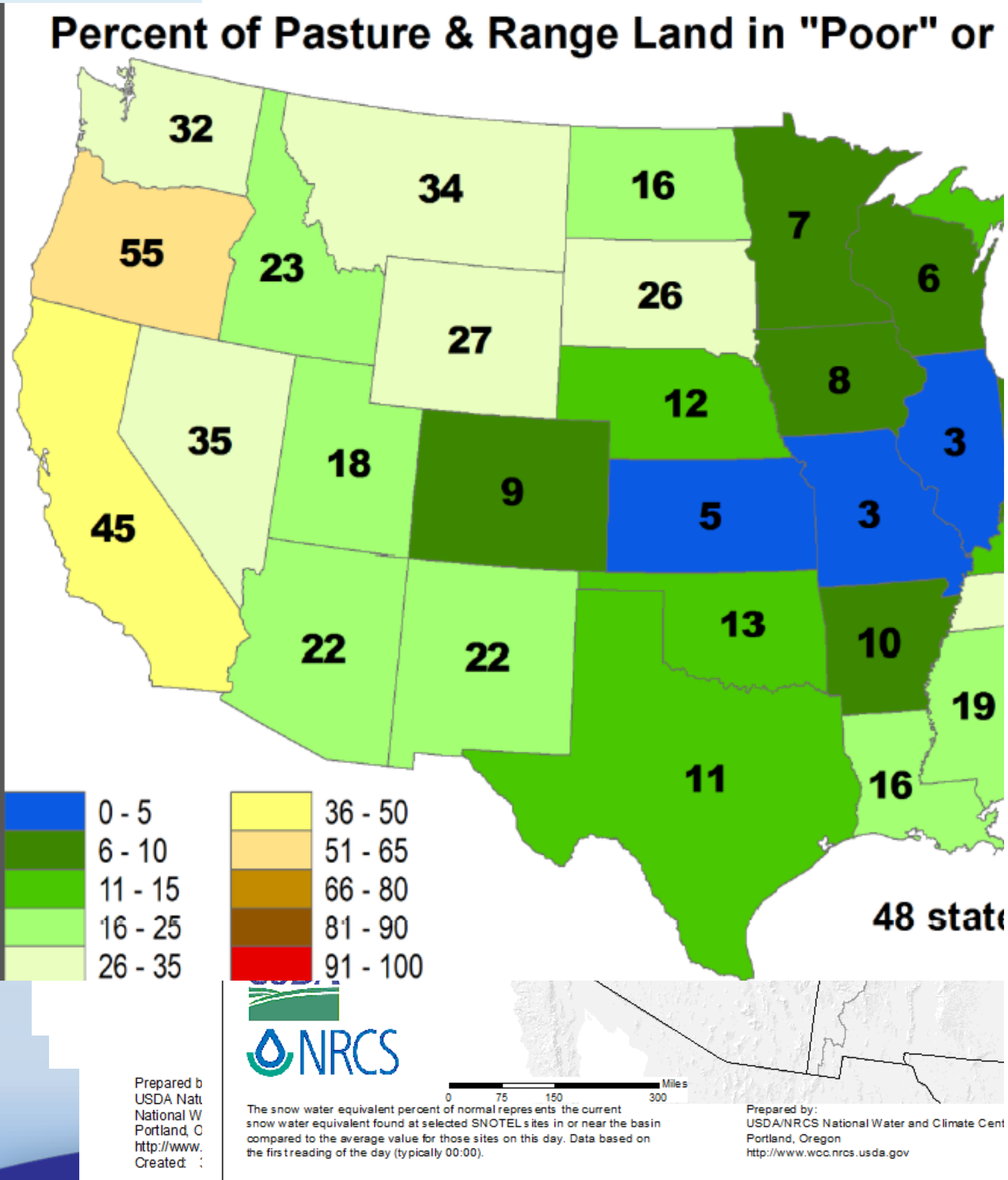


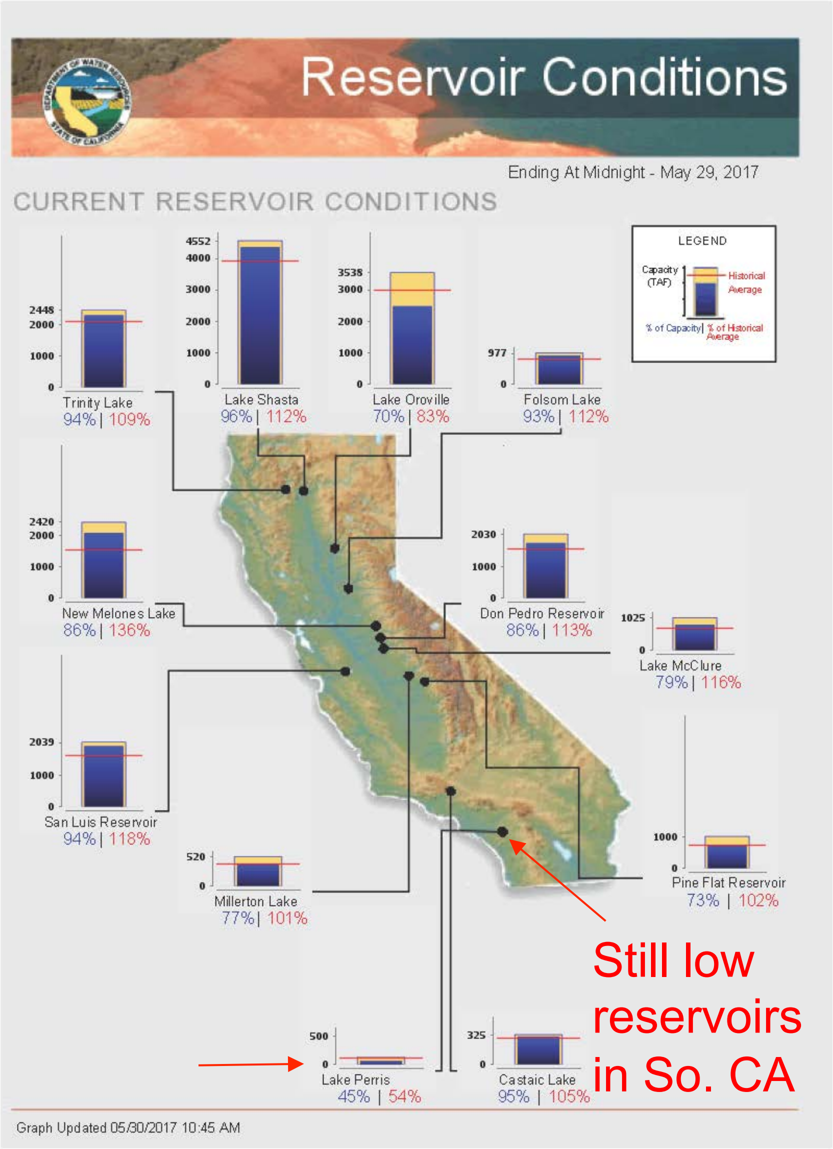
36-month
precip deficit



72-month
SPEI

USDM Status Based on Many Indicators





Still low reservoirs in So. CA

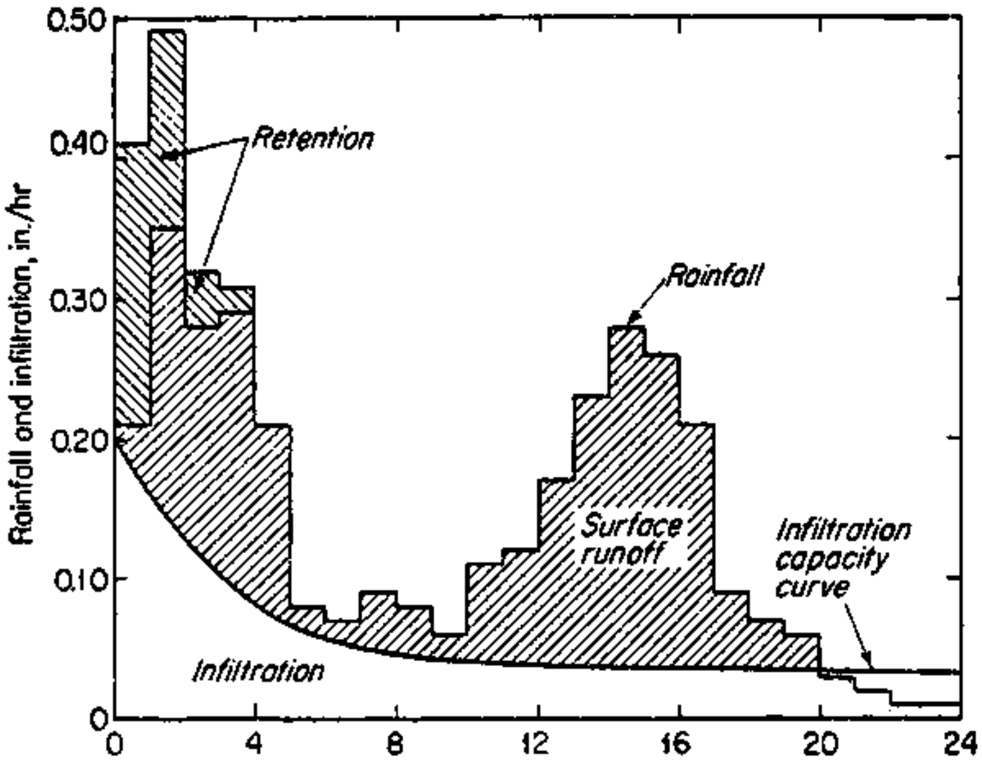
Why Don’t Heavy Rains End a Drought?

- Types of Drought:
  - Meteorological Drought
  - Hydrological Drought
  - Agricultural Drought
- Time Scales of Drought:
  - Short-term Drought
  - Long-term Drought

3.5.1 The surface runoff process

When rain falls, the first drops of water are intercepted by the leaves and stems of the vegetation. This is usually referred to as interception storage.

Figure 8 Schematic diagram illustrating relationship between rainfall, infiltration and runoff (Source: Linsley et al. 1958)



As the rain continues, water reaching the ground surface infiltrates into the soil until it reaches a stage where the rate of rainfall (intensity) exceeds the infiltration capacity of the soil. Thereafter, surface puddles, ditches, and other depressions are filled (depression storage), after which runoff is generated.

The infiltration capacity of the soil depends on its texture and structure, as well as on the antecedent soil moisture content (previous rainfall or dry season). The initial capacity (of a dry soil) is high but, as the storm continues, it decreases until it reaches a steady value termed as final infiltration rate (see Figure 8).

The process of runoff generation continues as long as the rainfall intensity exceeds the actual infiltration capacity of the soil but it stops as soon as the rate of rainfall drops below the actual rate of infiltration.

The rainfall runoff process is well described in the literature. Numerous papers on the subject have been published and many computer simulation models have been developed. All these models, however, require detailed knowledge of a number of factors and initial boundary conditions in a catchment area which in most cases are not readily available.

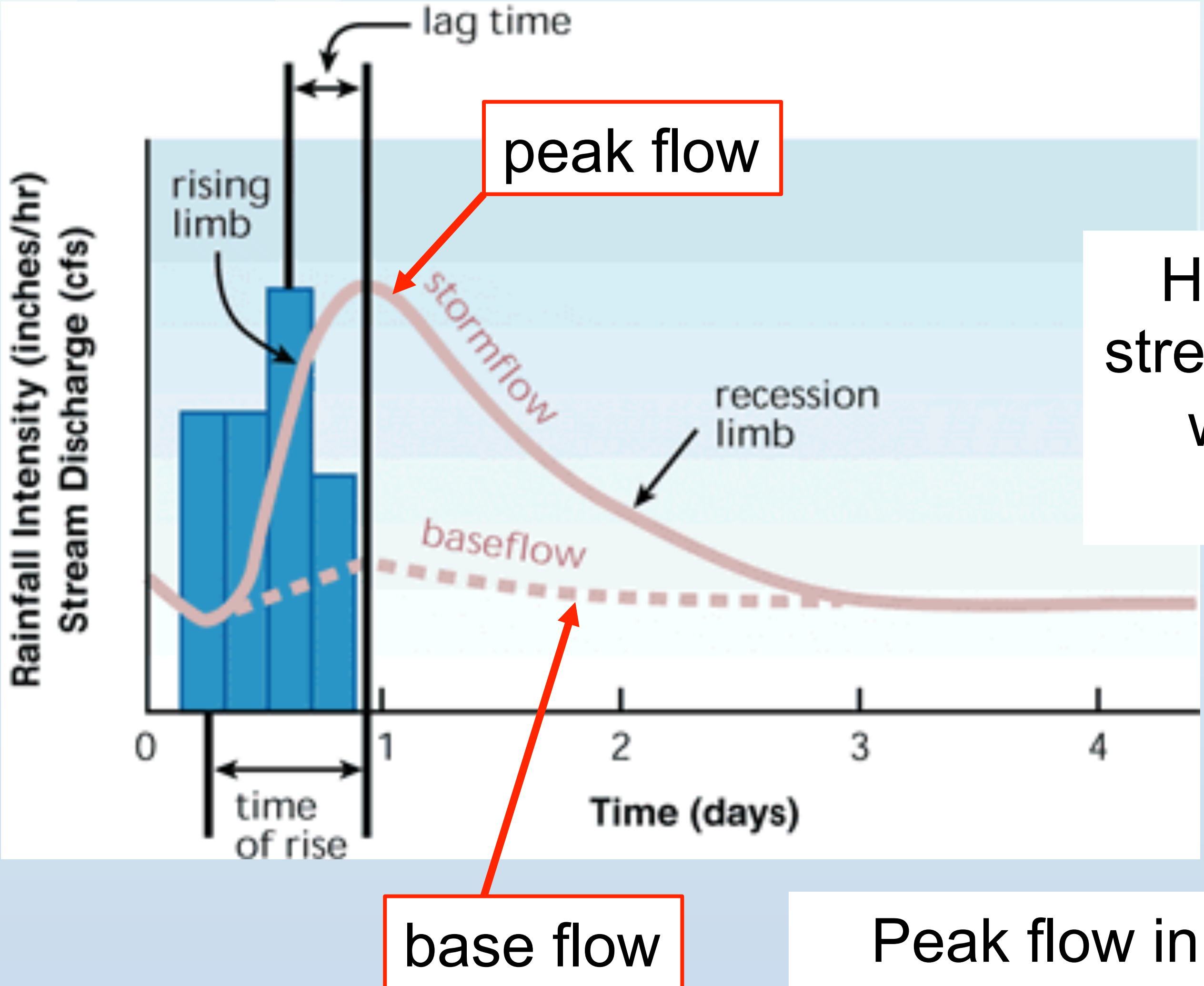
Why Don't Heavy Rains End a Drought?

Rainfall rate > Infiltration rate = Runoff

If the runoff isn't captured in storage (reservoirs), it is lost to the sea.

http://www.fao.org/docrep/u3160e/u3160e05.htm

Why Don't Heavy Rains End a Drought?



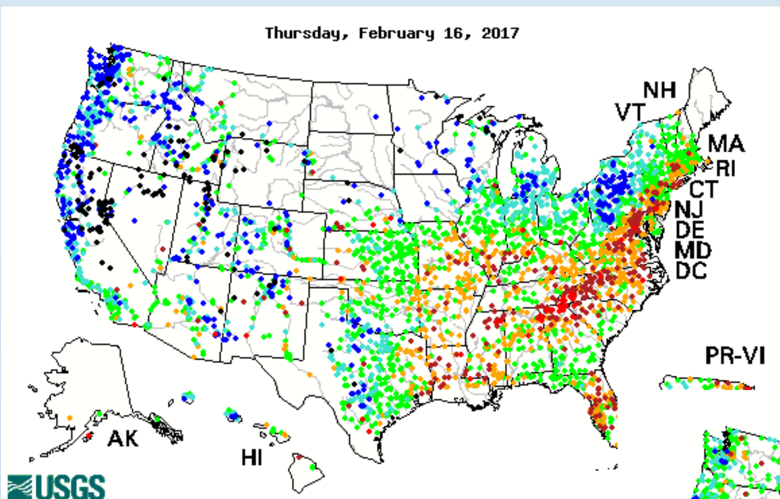
Heavy rains increase streamflow, which results when rainfall rate > infiltration rate.

Base flow is generally fed by groundwater.

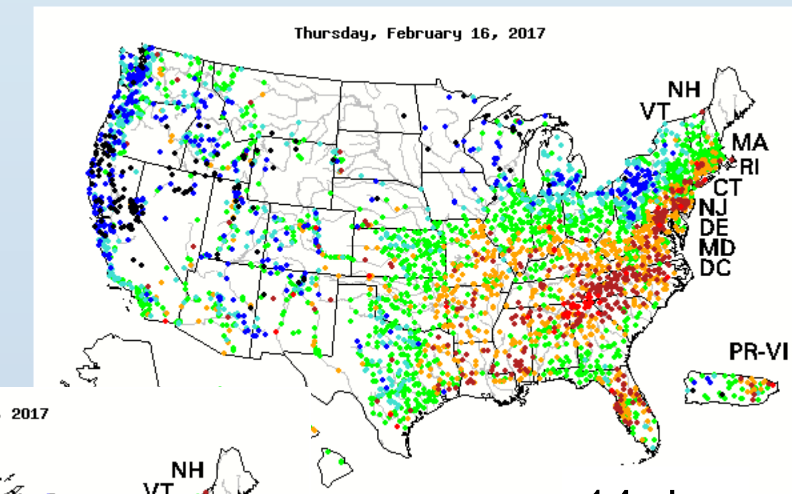
Peak flow in a hydrograph is useful for flood forecasting, but not for drought monitoring. Base flow should be used for drought monitoring.

Streamflow and Drought Monitoring

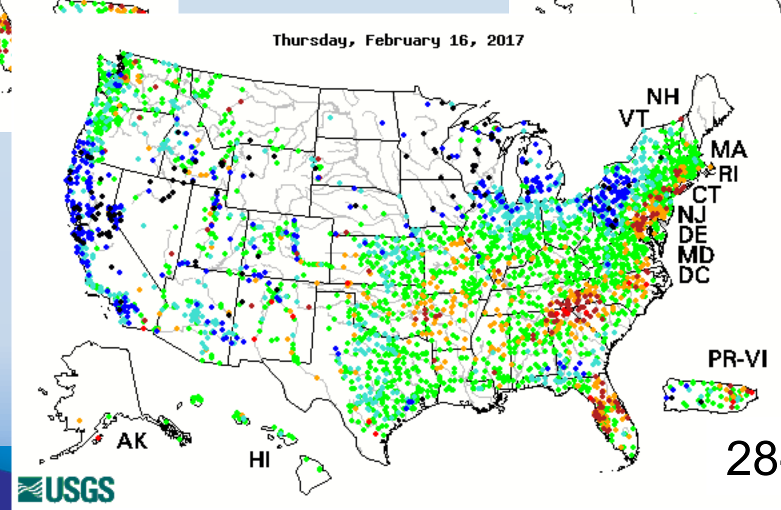
- Baseflow should be used for drought monitoring
- Baseflow generally is not available.
- So average the streamflow to average out the peak flow.
  - 7-day, 14-day, 28-day average streamflow percentiles



7-day



14-day



28-day

Why Don't Heavy Rains End a Drought?

- Strong seasonality of precipitation in the West (esp. CA).
- Heavy winter/spring snowpack needed – meltwater throughout summer for dry season water supply.
- Heavy winter rains, that don't produce mountain snowpack, don't help to end drought.
- Heavy rains, where rainfall rate exceeds infiltration rate, don't help much to end drought.
- For CA, ideally want above-normal wet season precipitation that increases snowpack and refills reservoirs.

Drought Recovery Tools

- Use with caution ***any*** metric that specifies amount of precipitation needed to end or ameliorate drought.
  - Precipitation to make up X deficit over Y months
  - Precipitation needed to get PHDI to -0.5
- Need to know exactly what the drought recovery tool tells you and how to use it.

https://www.ncdc.noaa.gov/temp-and-precip/drought/recovery-tools/

Drought Recovery Tools

Climate Monitoring
State of the Climate
Temp, Precip, and Drought
Climate at a Glance
Extremes
Societal Impacts
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GHCN Monthly
Monitoring References

Overview | Why It's Hard to Estimate Precip Needed to End Drought | Differences between Tools | Links

Overview

When determining how much precipitation is needed to end a drought, you need to be aware of what each drought recovery tool is telling you and what their limitations are. Many different drought recovery tools have been developed over the years based on different approaches for estimating the amount of precipitation that is needed to end drought. These tools sometimes give conflicting information. This web page was developed to clarify the different tools provided by the National Oceanic and Atmospheric Administration (NOAA) to enable water managers and other decision makers and users to better understand the different approaches and methodologies so they may better utilize the drought recovery tools.

https://www.ncdc.noaa.gov/temp-and-precip/drought/recovery-tools/

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Why It Is Hard to Estimate Precipitation Needed to End Drought

Drought is defined in general terms as an imbalance between natural water supply and water demand resulting from an unusual weather pattern. Reduced water supply is generally manifested by a deficiency of precipitation, while increased water demand is generally manifested by enhanced evapotranspiration (the combination of evaporation from free water surfaces and transpiration of water from plant surfaces to the atmosphere). Changes in these components caused by man (for example, reduced water supply due by water management decisions, and increased demand due to agricultural, urban and industrial activities) complicate the picture. Also, complex hydrological processes and water management practices (for example, diversion and storage of water by reservoir management systems) affect the quantity of precipitation required to end or ameliorate (reduce the severity of) a drought. Different drought recovery tools have been developed to address different hydrological processes.

For example, drought which occurs over several years will deplete soil moisture and reduce snowpack and stream, groundwater, lake, and reservoir levels. The amount of precipitation needed to replenish soil moisture to enable ecosystems and unirrigated agriculture to recover is less than the amount needed to restore depleted groundwater, lake, and reservoir levels. Groundwater recovery depends on infiltration rates determined by type of soil, and the infiltration zone may be many miles from where groundwater is measured. In the mountain hydrology of the western U.S., the gradual spring and summer melting of a heavy winter mountain snowpack is essential for maintaining the level of streams during the warm season. A few months of heavy precipitation will restore soil moisture in the topsoil and raise instantaneous streamflow levels, but may not be enough for the groundwater and reservoirs to recover. A few more months of precipitation may eventually raise reservoir and lake levels, but wells may still be going dry because groundwater hasn't been restored, and if the precipitation falls as rain instead of snow, the winter mountain snowpack will not have been replenished so the spring and summer meltwater source won't be available to maintain summer streamflow and reservoir levels. In summary, not only is the amount of precipitation important, but the timing of when that precipitation falls during the year, and the form of precipitation (rain vs. snow) affects recovery from drought.

https://www.ncdc.noaa.gov/temp-and-precip/drought/recovery-tools/

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Home | Climate Information | Data Access | Customer Support | Contact | About | Search

Home > Climate Monitoring > Temperature, Precipitation, and Drought > Drought Recovery Tools

May US Release: Wed, 7 Jun 2017, 11:00 AM EDT

Drought Recovery Tools

- Climate Monitoring
- State of the Climate
- Temp, Precip, and Drought
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Differences between Drought Recovery Tools

The basic root cause of a drought is lack of precipitation, so the early drought indices were largely someway of measuring or expressing the precipitation deficit and included such indices as precipitation deficit, percent of normal, or number of days since the last significant rain. Beginning with the Palmer Index in the 1960s, more sophisticated drought indices and models were developed which incorporate a measure of water supply (usually precipitation), water demand (usually evapotranspiration based on temperature), and water storage (a soil moisture, reservoir, or snowpack component) and which address the integrated total moisture status.

Precipitation Deficit — One of the simplest tools and easiest to understand, the precipitation deficit simply tells you how far behind normal the precipitation that has fallen is. The longer a drought lasts and more severe it is, the greater the precipitation deficit. In order to recover from a drought, one needs to get the normal precipitation plus enough precipitation beyond normal to erase the deficit. Comparing the amount of precipitation that has fallen to the historical precipitation record allows you to compute its historical rarity (sometimes expressed as a percentile). Comparing the size of the precipitation deficit (how much precipitation is needed to recover) to the historical record allows you to compute the probability of getting the needed precipitation (the probability of ending the drought), based on the climatological record. Tools based solely on the amount of precipitation don't take into account the form of precipitation (rain vs. snow) or other components of the hydrologic system (such as soil moisture, reservoirs, groundwater, etc.).

Multi-Station Indices — The California Department of Water Resources uses a *5-Station Index for San Joaquin precipitation*, an *8-Station Index for Northern Sierra precipitation*, and a *6-Station Index for Tulare Basin precipitation*. These are high-elevation stations located in the headwaters of these regions. Cumulative daily and monthly totals of precipitation are computed and compared to normal as well as to historical dry and wet years. These multi-station indices deal with just precipitation, they don't take into account the form of precipitation (rain vs. snow) or other components of the hydrologic system (such as soil moisture, reservoirs, groundwater, etc.).

Standardized Precipitation Index (SPI) — The SPI is based on precipitation amount which is converted, using a statistical method, into a standardized index that is positive for wet spells and negative for droughts. The more negative the number, the more severe the drought. Converting to a standardized index allows you to directly match the specific SPI value to specific levels of severity and compute a probability (non-exceedance level) of that value happening based on the statistical method used. The International Research Institute for Climate and Society (IRI) at Columbia University worked with the NOAA Earth System Research Laboratory and Climate Prediction Center to develop a computer model that converts predicted precipitation into a forecasted SPI value. The forecasted SPI values are used to predict future drought conditions. Since it is based only on precipitation amount, the SPI doesn't take into account the form of precipitation (rain vs. snow) or other components of the hydrologic system (such as soil moisture, reservoirs, groundwater, etc.).

Palmer Drought Index — The Palmer model uses a water budget methodology and series of equations to calculate a drought index (the PHDI, or Palmer Hydrological Drought Index, and PDSI, or Palmer Drought Severity Index) based on precipitation and temperature observations as input. It incorporates water supply (precipitation) and water demand (evapotranspiration based on temperature) and has a soil moisture component. Like the SPI, negative values indicate drought and positive values indicate wet spell conditions. A PHDI value of -2.0 indicates moderate drought, with the severity of drought increasing as the number becomes more negative. The equations can be reversed to calculate the amount of precipitation needed to change the PHDI value from very negative back to -2.0 (ameliorate drought) or back to -0.5 (end drought). So the quantity of precipitation computed using the Palmer model tells us how much is needed to end a meteorological drought and replenish soil moisture, but it tells us nothing about groundwater or reservoir replenishment or snowpack. NOAA's National Centers for Environmental Prediction (NCEI) compute the Palmer index on a monthly time scale, and NOAA's National Weather Service Climate Prediction Center (CPC) computes the Palmer index on a weekly time scale. These different time scales can result in different answers for the same question.

Water Supply or Hydrologic Forecast Models — Several models have been developed by state and federal agencies to forecast various components of the hydrologic system (such as river and reservoir conditions, snowpack, soil moisture). Inputs to the models include observed and forecasted precipitation, temperature, freezing levels, snowpack information, and streamflow. The models calculate future hydrologic conditions, mainly predicted streamflow. By comparing the forecast to historical data, the forecasted values can be expressed in statistical or probabilistic forms and using various scenarios. One hydrologic tool used by the western states is the *Surface Water Supply Index (SWSI)*. The SWSI is a predictive indicator of total surface water availability within a watershed for the spring and summer water use seasons. It is calculated by combining pre-runoff reservoir storage (carryover) with forecasts of spring and summer streamflow. The SWSI's scale runs from negative values for dry conditions to positive values for wet conditions to be consistent with the scales for the Palmer Drought Index and SPI. While these hydrologic forecast models do not tell us how much precipitation is needed to end a drought, they do incorporate variables important in western hydrology (snowpack, streamflow, reservoir levels) and provide hydrologic forecasts which are important for river and reservoir management.

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Links

NCEI Palmer-based web page for amount of precipitation needed to end or ameliorate drought

CPC Drought Monitoring (Palmer-based for amount of precipitation needed to end or ameliorate drought)

IRI Drought (SPI-based)

California Department of Water Resources - Precipitation

USDA Spring and Summer Streamflow Forecast Maps

State Surface Water Supply Index (SWSI) products https://www.ncdc.noaa.gov/temp-and-precip/drought/recovery-tools/

Thank You!